SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR DECEMBER, 1916.

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[Dated: Weather Bureau, Washington, D. C., Jan. 17, 1917.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE HAWAIIAN AND ALEUTIAN ISLANDS, ALASKA, AND THE MIDDLE ATLANTIC OCEAN.

Over the Hawaiian Islands moderately high pressure prevailed during the first week of December, 1916, with a slight reaction afterward until the 16th, after which normal conditions prevailed until the 17th. A steady fall then set in, reaching its lowest point on the 24th, after which there was a rise to normal conditions that prevailed until the end of the month.

Over the Aleutian Islands, as indicated by the reports from Dutch Harbor, the alternations of pressure were quite rapid and irregular. There was, however, a prolonged period of low pressure covering the 6th to 18th, inclusive, with a brief intermission on the 14th and 15th. After the 19th marked high pressure prevailed for five days, followed by another period of five days of low pressure. At the end of the month pressure was somewhat above normal. Over eastern Siberia high pressure was the rule. It was nearly normal during the first four days of the month, quite high for four or five days thereafter and moderately low on the 11th and 12th, after which a rise set in that steadily increased until the 23d and 24th, when the barometer read 31.10 inches. After that date there was a moderate fall but at the end of the month the pressure was still above normal.

Over Alaska marked low pressure during the first four days of the month was followed by a reaction of a fluctuating character, but nevertheless pronounced, that continued until the 13th, after which time moderately low pressure predominated, followed on the 20th by another period of high pressure until the 28th, inclusive. During the last few days of the month there was a decided fall to much below normal conditions.

The pressure conditions of Alaska were reflected, after the usual time interval, throughout the western portion of the United States. Over the eastern portion of the United States low pressure prevailed quite generally throughout the month until the last few days and, as the text following will show, there were a number of severe storms, mainly of the western type, that swept down into the Gulf States and then turned northeastward. In the Canadian Maritime Provinces pressure was remarkably low throughout the month, with the exception of a very few days when conditions were approximately normal.

The reports from Bermuda and Turks Island show that over the middle and southern portions of the North Atlantic, pressure was fairly steady throughout the month, with the exception of two periods in Bermuda. There pressure was quite low from the 16th to the 19th, inclusive, and high during the last week of the month, with high pressure extending well to the southward over the southern North Atlantic.

WASHINGTON DISTRICT WARNINGS.

On the morning of December 1 a disturbance of fair proportions was central north of Lake Superior with cool high pressure over the South. Moderately strong winds being indicated over the Great Lakes, small-craft warnings were accordingly ordered on the lower Lakes from Cleveland to Oswego, and fresh to strong southwest winds occurred during the day, extending also over the extreme western part of Lake Erie and southern part of Lake Huron. Warnings of possible light frost on the following morning were also issued on the morning of the 1st, for southern Georgia and the South Carolina coast. Light frost occurred on the morning of the 2d over southern Georgia, and light to heavy frosts along the middle Gulf coast.

During the 5th, the greatly increased development of a disturbance while crossing the upper Lakes caused local strong winds of brief duration for which no warnings had been ordered. The disturbance reached the lower St. Lawrence Valley by the morning of the 6th, and northwest storm warnings were ordered from Sandy Hook to Eastport. West and northwest gales followed, except on the northern New England coast, with a maximum velocity of 72 miles an hour at New York City.

Storm of December 5–9.—This storm first appeared on the coast of Oregon on the morning of December 5. By 3 p. m. of the following day it was over Nebraska with steadily increasing intensity, with moderately high pressure to the southeastward and northwestward. Northeast storm warnings were ordered at 5:30 p. m. for Lake Superior, and southeast warnings for Lakes Michigan and Huron. On the morning of the 7th the storm was central over southeastern Minnesota, with a narrow trough of low pressure extending southwestward into Oklahoma, and thence westward into New Mexico. Southeast storm warnings were then ordered for the lower Lakes, and in the early evening the warnings were ordered to be continued on the upper Lakes. The storm did not develop any considerable energy although pressure was quite low (29.60 inches), and only moderately strong winds occurred in a few localities. In the meantime the southwest section of the disturbance moved eastward, and at 8 p. m. of the 7th it was central over northeast Texas with a northeastward movement. Southeast storm warnings were therefore ordered along the Gulf coast from Bay St. Louis to Cedar Keys. Pressure was rising rapidly and decidedly to the westward of the disturbance, accompanied by a marked fall in temperature, and the evening forecasts of the 7th and the morning forecasts of the 8th contained a warning of freezing temperatures in Mississippi during the night of the 8th and much colder weather for the entire South. The southern section of the storm moved rapidly northeastward during the night of the 7th–8th, and on the morning of the 8th it had practically joined the northern section. The storm warnings were then lowered on the upper Lakes and along the Gulf coast. However, during the 8th the storm redeveloped considerably, and at 3 p. m. southwest warnings were again ordered on the lower Lakes. No further warnings were ordered for the upper Lakes at the time, and by the

morning of the 9th pressure had fallen still more over the lower Lakes and north upper Lake region, but as yet without strong winds over the latter section. Northwest warnings were ordered for Lake Huron, the east shore of Lake Michigan, and on Lake Superior from Houghton, Mich., eastward. Gales occurred on the lower Lakes as forecast, but there were no winds of consequence on the upper Lakes. Southwest storm warnings were also ordered on the Atlantic coast from Delaware Breakwater to Portland, and at 3 p. m. the southwest warnings on the lower Lakes were changed to northwest. Only moderately strong winds followed these displays and all warnings were ordered down at 9:30 p. m. of the 9th, the storm having moved northeastward beyond Ontario. As stated above, an extensive high pressure area of considerable magnitude followed this storm, and by the morning of the 8th its eastern quadrants covered the Plains States, with the crest over Colorado. Special observations at 1 p. m. indicated clearing weather in the Gulf and South Atlantic States, and at 2:30 p. m. cold-wave warnings were ordered for southern Kentucky, western Tennessee, and Mississippi, and warnings of freezing temperature and heavy frost for Alabama, western Georgia, and northwest Florida. At 9 p. m. special warnings of frost on the morning of the 10th were sent to central and north Florida. Low temperatures and frosts occurred as forecast except in central and northeast Florida where cloudiness prevented any decided fall in temperature.

Storm of December 8–12.—This disturbance was an offshoot from a more extensive one over the Aleutian Islands, and reached Alberta on the morning of December 8. It moved southeastward to the Texas Panhandle and then turned eastward and northeastward. At 8 p. m. of the 10th, the center was over northwest Arkansas, with pressure falling rapidly to the northeastward, and northeast storm warnings were ordered at 10 p. m. over south Lake Huron and Lake Erie for strong northeast winds and snow on the following day. While the barometer continued to fall during the northeastward movement of the disturbance, reaching 29.42 inches over western New York, no strong winds occurred owing to the approach of another disturbance from the West. However, on the morning of the 12th, the pressure gradients were so marked as to call for northwest storm warnings from Wilmington to New Haven, and northeast warnings from Saybrook Point to Boston, afterwards extended to Eastport, Me. These warnings were not due so much to the northern storm as to a secondary one that first appeared in very faint form on the morning of the 11th at the mouth of the Mississippi River. It moved northeastward with rapidly increasing intensity, and on the morning of the 12th was central off the North Carolina coast with a barometer reading of 29.34 inches. The two storms joined during the day, and at 8 p. m. the single storm was central over eastern Maine with a barometer reading of 28.76 inches at Eastport. Fresh to strong gales, mostly from the northwest, had occurred from North Carolina northward diminishing considerably by the morning of the 13th. The rise in pressure after this storm was not marked, another low pressure system following closely, and cold-wave warnings ordered at 10 p. m. of the 10th for northern Kentucky, Indiana, and western Ohio, were not verified.

Storm of December 12–16.—This storm first appeared on the evening of December 12 over southwestern Montana. By 1 p. m. of the 14th it had moved to southeastern Texas in moderate form, and then turned northeastward. By 8 p. m. of the 14th it had reached southwestern Alabama, and at 10 p. m. northwest warnings were ordered displayed on the Gulf coast from Bay St. Louis, Miss., to Rockwell, Fla., and on the Atlantic coast from Jacksonville to Savannah; also southeast warnings from Charleston to Delaware Breakwater. As a HIGH of considerable strength was following closely, warnings of freezing temperature were issued for the interior and of heavy frosts on the coasts of Mississippi, Alabama, and northwestern Florida, and warnings of cold weather for west Tennessee. The warnings sent to Mobile, Ala., and Pensacola, Fla., were for cold waves, and at 9:30 p. m. cold-wave warnings were also ordered for Alabama, southwest Georgia, and north Florida. Warnings were also issued of heavy frost on the morning of the 16th for central Florida. At 8 a. m. of the 15th the storm was central over the Carolinas, and during the day moderate westerly gales occurred in the districts warned. Northeast storm warnings were also ordered on the morning of the 15th from Atlantic City to Boston, and at 3 p. m. on the remaining portions of the New England coast. By the morning of the 16th, northeast to northwest gales had occurred as forecast, with a whole gale off the New England coast. Eastport, Me., reported a wind velocity of 76 miles an hour from the northeast. At 10 p. m. of the 15th the northeast warnings were changed to northwest from Atlantic City to Boston, and at 10 a. m. of the 16th from Marblehead, Mass., to Eastport. The winds subsided during the 16th, and on the morning of the 17th the storm had passed into the Atlantic Ocean by way of Cape Breton Island.

On the morning of the 15th the cold wave had extended through Alabama and extreme northwestern Florida, and by the following morning throughout the South Atlantic States generally, and into southern Virginia, with freezing temperature in the interior of central Florida, as had been forecast on the evening of the 14th and the morning of the 15th. Warnings of freezing temperature and heavy frost for Georgia and northern and central Florida, repeated on the morning of the 16th, were found on the following morning to have been verified for Florida only, Bartow reporting killing frost with a minimum temperature of 26°. The warning in Georgia failed through the southeastward movement of the high area over Florida.

During the passage of the storm up the Atlantic coast snow fell in considerable quantity, and at 2 p. m. of the 15th a heavy-snow warning was issued for New England and eastern New York. This warning was fully verified. This storm was by far the most severe of the month on the New England and Middle Atlantic coasts. At Eastport, Me., the records of 45 years were exceeded in three particulars: First, the low barometer reading of 28.52 inches; second, the extreme wind velocity of 96 miles per hour; and third, the 24-hour snowfall of 17 inches on the level ground.

Storm of December 14–15.—This storm first appeared on the morning of the 14th over northern Saskatchewan. By 8 p. m. of the 14th it was central over northwest Minnesota, and northeast storm warnings were accordingly ordered for Lake Superior and southeast warnings for Lakes Michigan and Huron. The storm continued eastward over the Lakes, with diminishing intensity, and there were no strong winds except over western Lake Superior.

Storm of December 17–19.—On the morning of the 17th there was a moderate disturbance over northeastern Texas, and it moved southeastward to Louisiana during the day, with increasing intensity. In the evening of that day small-craft warnings were ordered to be displayed on the morning of the 18th from Mobile, Ala., to

Apalachicola, Fla. By the morning of the 18th, however, the storm was over northeast Alabama, with a considerable increase in intensity, and northeast storm warnings were ordered from Boston to Baltimore, southeast warnings from Chincoteague Island, Va., to Wilmington, and southwest warnings from Southport, N. C., to Jacksonville, Fla., with orders to change the latter to northwest at sunset.

Special observations at 1 p. m. indicated that there would be strong northwest winds on the east Gulf coast, and at 3 p. m. northwest storm warnings were ordered from Carrabelle to Tampa, Fla. The disturbance was then over South Carolina with an apparent northeastward movement, and the northeast storm warnings on the New England coast were therefore extended to Eastport, Me. The 8 a. m. forecast of the 18th also contained warnings of heavy snow for southern New England and the Middle Atlantic States, and the storm warnings of the afternoon were supplemented by an additional warning to all coast stations concerned to exercise great caution, as severe gales with heavy snow were probable north of Virginia. However, the storm center moved off the North Carolina coast, more to the eastward than had been anticipated, and as a result there were no gales nor snow of consequence north of New Jersey. Warnings of heavy snow issued on the morning of the 18th for western New York, western Pennsylvania, and southeastern Ohio also failed of verification, owing to the eastward movement of the southern storm.

The rapid movement of this storm and the equally rapid approach of cold weather from the West necessitated the issue, during the morning and afternoon of the 18th, of cold-wave warnings for eastern Mississippi, Alabama, Georgia, northern Florida and South Carolina, and of heavy frost warnings for central Florida. These warnings were fully verified by the occurrences on the morning of the 19th, by which time the disturbance had passed northeastward beyond New England and the storm warnings had been lowered.

Storm of December 18–23.—The next disturbance from the northwest developed in very irregular shape. It appeared first on the morning of December 18 over northern British Columbia, and by the morning of the 19th it extended in crescent shape from western Montana southeastward to the Texas Panhandle and thence northeastward to Lake Michigan, with a strong and very cold HIGH to the northward. Cold-wave warnings were therefore ordered for northern Michigan, but they failed entirely of verification, owing to the persistence of the northeastern section of the disturbance. The northwestern section of the disturbance continued southeastward with increasing intensity, and on the morning of the 20th it was central over Arkansas, with a northeastward movement. Anticipating this movement, cold-wave warnings had been ordered on the previous evening for Kentucky, Indiana, southwestern Ohio, lower Michigan, western Tennessee, and Mississippi. These warnings were repeated on the morning of the 20th, for Mississippi, Tennessee, Kentucky, and Indiana.

On the evening of the 20th, with the storm central over Mississippi and a moderate secondary disturbance over northwestern Ohio, cold-wave warnings were ordered for West Virginia and southwestern Pennsylvania. These warnings also failed of verification, owing to the slow movement of the southern disturbance and of the high pressure to the westward. On the evening of the 21st the disturbance was over northeast Alabama, with an apparent northward movement. During the night, however, there was an extraordinary development, both in intensity and velocity of progress, and on the morning of the 22d the disturbance was over eastern Maryland in pronounced form, attended by general rains and snows but as yet without strong winds. Southeast storm warnings had been ordered on the morning of the 20th from Bay St. Louis, Miss., to Cedar Keys, Fla., but no strong winds resulted, owing to the limited development of the storm while in the South.

There had also been some indication of a further storm development in the southeast during the 21st, and at 6 p. m. of that day southeast storm warnings were ordered from Charleston to Fort Monroe, and strong south winds occurred as forecast. On the morning of the 22d, with the storm central over Maryland, northwest warnings were immediately ordered from Hatteras, N. C., to New London, Conn., and northeast warnings on the remainder of the New England coast.

The storm continued northeastward during the 22d and at 8 p. m. was central over Maine, with a pressure of 28.76 inches at Portland, and severe westerly gales had occurred, with a maximum of 88 miles an hour at New York City and 72 miles an hour at Block Island. The storm soon passed beyond the borders of the State of Maine and the warnings were lowered on the following morning.

A high-pressure area of fair proportions followed this storm, attended by another decided fall in the temperature over the Ohio Valley and the South. On the evening of the 21st cold-wave warnings were ordered for western Tennessee, Alabama, Georgia, northern Florida, South Carolina, and western North Carolina, and on the morning of the 22d for the greater portions of the upper Ohio Valley, the middle and the southern Atlantic States. These warnings were well verified in the South but only partially so elsewhere, although the temperatures were much below the seasonal average.

Storm of December 19–25.—This storm first appeared off the North Pacific coast on the evening of December 19 and by the night of the 25th had reached southeastern Colorado, with steep pressure gradients to eastward and southeastward. Small-craft warnings were therefore ordered to be displayed on the following morning over the middle Gulf coast. By that time, however, the storm had separated into three sections—one over western Colorado, with diminishing intensity, one over eastern South Dakota, moving northward with increasing intensity, and a third over eastern Texas. Owing to this latter secondary disturbance the small-craft warnings were changed to southeast storm warnings at 11 a. m. of the 26th, from Bay St. Louis, Miss., to Rockwell, Fla., and northeast warnings were ordered from Fort Monroe, Va., to Jacksonville, Fla. By the morning of the 27th the northern section was central over eastern Manitoba with about the same intensity and with the southern section still over the west Gulf States, with apparently diminishing intensity, but with some evidences of further development. The high-pressure area over the Atlantic Ocean and adjacent States had fallen materially, and no strong winds of consequence occurred on the southern North Atlantic coast.

As pressure had risen rapidly in the rear of the main disturbance, accompanied by marked fall in temperature to much below normal conditions, cold-wave warnings were ordered for upper western Michigan, lower Michigan, except along the west shore, northwestern Ohio, Indiana, southern Kentucky, western Tennessee, and northern Mississippi. These warnings were well verified as to Michigan but only partially so over the remaining sections where ordered.

Advisory warnings of strong winds, with snow, were sent to the upper ports of Lake Michigan on the 19th, 23d, and 25th; the two latter were fully verified, while the first one failed.

OTHER DISTRICT WARNINGS DURING DECEMBER.

Chicago district.—The month was marked by temperature above the normal during the first week over practically the entire district, while during the balance of the month, with only slight interruptions, the readings were below, so that for the month as a whole the temperature averaged below the seasonal normal. The departures in the Northwest were considerable, ranging in Montana and North Dakota from 8 to 15 degrees.

Warnings were issued on the morning of the 10th for cold waves for the western portion of the district, and these were extended eastward over the greater portion of the district during that day and evening. At the same time cautionary warnings were issued to the western ranchmen to protect their cattle on the ranges, as snow and strong winds were anticipated in addition to the fall in temperature. Colder weather quickly overspread the entire district, but the severe cold was retarded so that the cold wave was not felt in full force in the Northwest until the 12th.

Warnings were issued on the 17th and again on the 19th for cold waves which moved directly southward over the Plains States from the British northwest, causing very low temperatures as far south as the Kansas border by the 20th. The waves finally extended eastward over the entire district with considerable intensity.

Following the movement of these cold waves, a severe storm developed in the West, which later proved to be by far the most important of the entire month. It appeared on the north Pacific coast on the 20th and gradually pushed southeastward over the plateau, crossing the Rocky Mountain region on the 25th. The storm then took an unusual course northeastward, moving first across the northern Plains States to Manitoba, thence directly eastward. The depression was rather deep, and attendant storm conditions were correspondingly severe. Special warnings were ordered on the 24th, 25th, and 26th, covering the movement of these storm conditions, and live-stock warnings were issued to the western ranges on the 25th. The snowfall in some of the Western States was especially heavy, and because of accompanying high winds drifted badly.—*H. J. Cox, Professor of Meteorology.*

New Orleans district.—A decided cold wave overspread the district on December 8 and 9, for which timely warnings were issued.

Special observations at 1 p. m. on the 10th showed a storm area centered over Oklahoma with decided anticyclonic weather to the northwestward; therefore, cold-wave warnings were ordered at 3:30 p. m. for stations in Oklahoma and at Bentonville, Ark., and Abilene, Tex., and at 10 p. m. were extended to Fort Smith, Ark. The anticyclonic conditions diminished in intensity and the warnings were only partially verified.

Cold-wave warnings were ordered at 9:45 p. m. on the 12th for Altus and Oklahoma and on the morning of the 13th for Little Rock. The low temperatures moved southward more slowly than was anticipated and the warnings were not fully verified.

An area of low pressure over eastern Texas with an area of high pressure over the Plains States on the morning of the 14th, gave a cold wave over eastern Texas and Louisiana on the 14th and 15th for which timely warnings were issued.

An intense cold wave reached the northwestern portion of the district on the morning of the 20th and passed over the southeastern portion of the district on the morning of the 22d. Cold-wave warnings were ordered at all stations well in advance of the cold wave.

Cold-wave warnings were ordered on the 25th for Oklahoma, Arkansas, and the interior of Texas, in the expectation that an area of low pressure centered over southwestern Kansas and extending southward over western Texas would move eastward and carry southward the cold air from the Missouri Valley and the Plains States. On the morning of the 26th the LOW was centered over eastern South Dakota and the warnings failed of verification.

Storm warnings ordered for the Texas coast on the 8th and 14th and the Louisiana coast on the 20th were justified. Small-craft warnings were displayed on the Louisiana coast on the 14th, 18th, and 20th and on the Texas coast on the 19th and were followed by winds which justified the display.

Fire-weather warnings were telegraphed to the forest supervisors, Harrison and Hot Springs, Ark., and Cache, Okla., on the 10th, 19th, and 25th and the conditions forecast occurred.—*I. M. Cline, District Forecaster.*

Denver district.—Moderately warm weather prevailed throughout the district until the morning of December 7, when the temperature fell sharply in western Colorado, southern Utah, and northern Arizona, following the rapid eastward passage of a disturbance from the north California coast. Cold-wave warnings were issued for eastern Colorado and eastern New Mexico, a part of the disturbance remaining over New Mexico. On the morning of the 8th temperatures fell to 4 to 10 degrees above 0°F. in eastern Colorado and northeast New Mexico, and 8 to 12 degrees below the freezing point in southeast New Mexico, amply justifying the warnings issued. A depression was central over the Texas Panhandle at 8 a. m. on the 10th, and warnings of a cold wave attended by snow were issued for eastern Colorado. Temperatures of 0° to 8° F. prevailed 24 hours later in eastern Colorado, and snow fell except at Pueblo, Colo. A cold high pressure area appeared over Saskatchewan on the 12th. Special observations at 1 p. m. disclosed a rapid southward movement and cold-wave warnings were issued for northeastern Colorado. At 8 p. m. these warnings were extended to southeastern Colorado. Temperatures ranging from 0° to 8° and 12° followed in eastern Colorado. A cold-wave warning was issued for Denver and vicinity at 8 a. m. December 17. By 9 p. m. of the same date the temperature at Denver had fallen to 8°F. Cold-wave warnings were issued for southeast New Mexico at 8 p. m. of the 17th, and a temperature of 16° below the freezing point was recorded at Roswell, N. Mex., the following morning. On the morning of the 19th a trough of low pressure overlay the eastern Rocky Mountain slope, with an anticyclone over Manitoba and eastern North Dakota. Generally this pressure distribution is not favorable for a cold wave in eastern Colorado, but it was expected in this instance that the greater part of the LOW would move into the lower Mississippi Valley and make way for rising pressure in eastern Colorado. On the morning of the 20th the weather was 20 to 30 degrees colder in eastern Colorado, with temperatures ranging from near 0° in the plains of eastern Colorado to 14° near the foothills. At 8 p. m. of the 19th the warnings were extended to eastern New Mexico. During the next 36

hours temperatures ranging from 0° to 12° occurred in eastern New Mexico, with 0° temperatures in eastern Colorado. At 8 p. m. on the 20th the warnings were repeated for southeast New Mexico and the temperature at Roswell fell 44 degrees within 12 hours.

An energetic storm appeared over eastern Nevada on the evening of the 24th, and warnings of heavy snowfall were issued for southern Utah, northern Arizona, and southwest Colorado, with a cold wave for Utah and portions of Colorado and Arizona. The warnings of heavy snowfall were fully verified, the snowfall ranging from 4 to 10 inches and upward, attended by low temperature. Christmas morning the storm was over Utah with a barometer reading of 29.12 inches at Modena. Cold-wave warnings were issued for Utah, Colorado, northern and western Arizona, and northwest New Mexico. The warnings were justified, temperatures below 0°F. being reported in portions of Colorado and Utah and freezing temperatures in southwestern Arizona on the 26th. Remarkably low temperatures continued in portions of Utah and Arizona during the remainder of the month. The Christmas storm caused serious delays in railroad operation, and considerable suffering occurred owing to the tardy receipt of coal and of foodstuffs. Heavy snowfall warnings were extended to northern New Mexico and eastern Colorado, but the snowfall at reporting stations was not heavy.

Frost or freezing temperature warnings were issued almost daily for portions of southern Arizona. No extensive damage was reported in this region, although temperatures well below freezing occurred on several dates.—*Frederick W. Brist, Assistant Forecaster.*

Portland, Oreg., district.—December, 1916, was unusually cold with less than the normal amount of precipitation. From the 6th to the 19th and again on the 26th and 27th the weather in this district was mostly controlled by high-pressure areas. The weather from the 2d to the 5th and from the 21st to the 25th was under the influence of North Pacific LOWS. During the last four days a LOW was central at sea near the mouth of the Columbia River. The barometer at the coast stations fell rapidly on the 27th and 30th and rose rapidly between these dates. This LOW was about to move inland when it surged back to sea without causing as much wind or rain as expected.

Storm warnings were ordered at one or more stations on 17 occasions, cold-wave warnings were ordered twice for portions of the district, and small-craft warnings were ordered four times. The storm warnings ordered during the first three days were fully verified, as maximum wind velocities of 80 miles an hour occurred at both Tatoosh Island and North Head. Storm warnings ordered on the 7th were followed by maximum wind velocities of 60 miles at North Head and 52 miles at Tatoosh Island.

On the 10th storm warnings were ordered displayed at the entrances to the Strait of Juan de Fuca and the Gulf of Georgia, as the barometric gradients were very steep between Tatoosh Island and Prince Rupert, with a 60-mile gale blowing at Prince Rupert. This storm moved rapidly eastward to Alberta without causing any high winds in this district. Storm warnings were ordered on the 18th and 19th which were not followed by verifying velocities at the coast stations, but high winds occurred at inland seaports.

Storm warnings were ordered during the early afternoon of the 19th in consequence of special observations received from Seattle and Tatoosh which showed a marked fall in pressure during the last two hours. A low-pressure area was central, that morning, over western British Columbia but did not appear to have sufficient energy to warrant the display of storm warnings. When the special observations were received it was thought a sudden development had taken place and that high winds would occur, as the velocity had already doubled at the two stations sending the special observations. No high winds, however, were reported in connection with this storm.

On the morning of December 21 a well-defined storm was central near the mouth of the Columbia River, and warnings were ordered displayed at all stations in this district. Shortly after these warnings were ordered the barometer began rising rapidly and at noon they were ordered down and small-craft warnings ordered up in their place, except at Marshfield where the storm warnings were continued. The highest wind during the passage of this storm was 56 miles, from the northwest, at North Head, Wash. It would have been better if small-craft warnings only had been displayed.

Storm warnings were ordered again on the 22d at all stations in this district, but no high winds occurred at any of the land stations. The barometer fell rapidly and a reading of 29.20 inches was reported at Tatoosh Island, Wash., on the morning of the 23d. The isobars inclosing this storm were wide apart at its center and close together near the outer edge of the depression, which accounts for the wind not being strong in this district. Gales in connection with this disturbance were severe along the California coast and presumably also along the southern Oregon coast.

On the 27th storm warnings were ordered at the entrance to the Strait of Juan de Fuca, and 10 hours later a maximum wind velocity of 48 miles was reported from Tatoosh Island, Wash. The last warning of the month was ordered at 6 p. m. on the 31st at the entrances to the Strait of Juan de Fuca and the Gulf of Georgia. It was followed by wind velocities of 48 miles an hour at Tatoosh Island and 64 miles at North Head.

Cold-wave warnings were ordered for a portion of the district on the 13th and 26th. The one ordered on the 13th was partially verified, but the one on the 26th was a failure, owing to the HIGH losing energy which was not foreseen at the time the warnings were ordered.

The sales manager of the Hood River Apple Growers' Association was advised on the 6th, 10th, 13th, and 25th of approaching cold weather along the Union Pacific Railroad in eastern Oregon and southern Idaho. This association was at the time shipping a large number of cars of apples to the eastern markets. The following extract from a letter received in acknowledgment of this service will show its worth:

> I want to acknowledge receipt of your wires and also at the same time my very keen appreciation of the excellent service. With this information coming from you and from Prof. Cox I am going to be able to guide better the destinies of this organization and the guidance of 2,000 cars of fruit, but I just want you to know how keenly I appreciate it.
>
> WILMER SIEG,
> *Sales Manager, Apple Growers' Association.*

Two special forecasts were sent during the month to the U. S. S. *Cheyenne*, which was cruising along the coast as the mother ship for some submarines that were investigating the facilities of the harbors in Washington and Oregon.—*E. A. Beals, District Forecaster.*

San Francisco district.—From December 1 to 5 the weather was unsettled, and rain with snow in the mountains prevailed in all sections. During the latter part of the first decade and all of the second decade the weather was fair and cold, with frequent killing frosts in all sections.

The third decade was a period of unsettled weather, generally with low temperatures and rapid changes from rain to fair weather at short intervals. During this period killing frosts occurred frequently. The most severe frost occurred on the morning of the 27th in southern California and damaged citrus fruit in some sections, but to what extent is not known at present.

More than the usual number of southerly gales occurred along the coast, and the storm warnings were timely in nearly every instance.—*G. H. Willson, District Forecaster.*

HURRICANES OF 1916 AND NOTES ON HURRICANES OF 1912-1915.

By RICHARD HANSON WEIGHTMAN.

[Dated: Weather Bureau, Washington, D. C., Feb. 5, 1917.]

The season of tropical storms of the year of 1916 in the West Indies was noteworthy on account of the large number of disturbances reported. In fact in only 2 previous years out of the last 40 were more storms noted—namely, in 1886 and 1887. Besides the nine more important storms noted in 1916 there were several minor disturbances which, although locally severe, were of such short duration that it was not thought advisable to chart them. The season was also remarkable for the number of disturbances of intense character within the Tropics.

Detailed descriptions of the storms that occurred during the hurricane season of 1916 are given in the issues of the MONTHLY WEATHER REVIEW for the respective months and contain all data available at the time the several numbers went to press. Data which have come to hand since the issues above mentioned are presented in this paper and tend to supplement rather than to change the information previously published. Deductions presented regarding origin, track, and intensity that differ from those previously given are based on more complete data. There follows a list of the hurricanes of the past season arranged in chronological order with a few brief remarks accompanying them. An attempt is made to give a rough idea of the intensity of the disturbances noted by the use of the terms slight intensity, moderate intensity, of severe intensity, etc., while an estimate of their extent is indicated by employing expressions such as slight, moderate, large, etc. It must be realized, however, that reports in most cases are widely scattered and that estimates such as indicated above are in a number of cases therefore merely estimates. The paths of the 1916 hurricanes are shown grouped by months on Chart X (XLIV–152) of this issue of the REVIEW.

Remarks concerning the previous history of storms are based on a study of Bulletin "X", Hurricanes of the West Indies" by Oliver L. Fassig.

Appreciation is hereby noted of a collection of reports from a number of the islands of the West Indies forwarded by Mr. Francis Watts, commissioner of agriculture, Barbados, British West Indies, and also of numerous and valuable reports from vessels at sea.

NOTES ON HURRICANES OF 1916.

July 1–10.—The disturbance originated in approximately latitude 16° N., longitude 84° W., attained moderate intensity after passing through the Yucatan Channel, and reached the Gulf coast of the United States immediately west of Mobile, Ala., as a severe storm. The lowest barometer at Mobile was 28.92 inches and the maximum wind velocity (maintained for 5 minutes), 107 miles an hour from the east. Penascola reported a maximum velocity of 104 miles an hour from the southeast. These velocities were records for their respective stations. The velocity at Pensacola was exceeded in the storm of October 18, 1916, a report of which follows.

In a way this storm may be said to have followed an average course for the month, in that it passed to the east Gulf coast after having originated in the western Caribbean Sea.

July 11–15.—This disturbance, as far as reports are available, seems to have originated immediately east of the Bahamas in about latitude 24° 30′ N. It moved northwestward to the South Carolina coast, passing inland over or near Charleston, S. C. The lowest pressure reading at that station was 29.02 inches and the maximum wind velocity 64 miles an hour from the northeast. The U. S. S. *Hector* in latitude 31° 45′ N., longitude 78° 53′ W., reported a barometer reading (aneroid) of 28.37 inches which, upon subsequent comparison of the instrument, is thought to be reasonably accurate. This disturbance was moderately severe in intensity and of small area.

This is the first July storm of record that passed northwestward from the region of the Bahamas and struck the south Atlantic coast.

July 12–22.—The origin of this storm was in about latitude 15° N., longitude 61° W. The center passed northwestward to latitude 29° and thence almost due north, striking the southern New England coast with diminished energy. The lowest pressure reading, 28.94 inches (aneroid), was reported in latitude 27° 30′ N., longitude 73° W., by the S. S. *Ausable* shortly after 1 a. m. of the 19th, with wind force 11–12. This disturbance was of moderate to great intensity and of moderate to large area.

There is only one other storm of record in July that originated in low latitudes so far to the eastward. That storm passed westward south of the islands of the Greater Antilles, while the storm of the present year passed northwestward, north of the Antilles.

August 12–19.—This storm had its origin in approximately latitude 14° N., longitude 56° 30′ W. It passed westward south of the Greater Antilles and through the Yucatan Channel, later striking the Texas coast a little south of Riviera, which is situated about 45 miles southwest by south of Corpus Christi. At Kingsville, about 14 miles north of Riviera, the lowest pressure reported was 28 inches (corrected) on an aneroid barometer, while at Del Rio, at 8 a. m. (75th meridian time) on the 19th, a pressure of 28.72 inches was observed. The highest wind velocity at Corpus Christi was about 90 miles an hour. The storm was severe and moderate to large in extent.

This disturbance followed an average course for the type of August hurricanes that passes through the Yucatan Channel.

August 22.—The disturbance passed south of Tortola (Virgin Islands) and across the island of Porto Rico on a course a little north of west, the lowest pressure reported at San Juan being 29.44 inches at 7 a. m., while the maximum wind velocity was over 90 miles an hour. The origin of this storm is very uncertain and, after crossing the island of Porto Rico, there is little if any trace of it to be found. It was of moderate intensity and extremely small area.

August 28–September 1.—The exact origin of the disturbance is unknown, but was undoubtedly some distance to the east of the island of Dominica. The first trace obtainable is at Roseau, Dominica, over or immediately south of which